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Preliminary investigation of scale formation and fluid chemistry at the Dixie Valley Geothermal Field, Nevada

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Potential approaches for additional power generation

- Bottoming cycle low-pressure flash
- Supplementing reinjection into the reservoir with local shallow groundwaters to maintain reservoir pressure

Oxbow conducted on-site scaling and mixing tests simulating plant and field conditions which produced variable scaling rates and scale properties

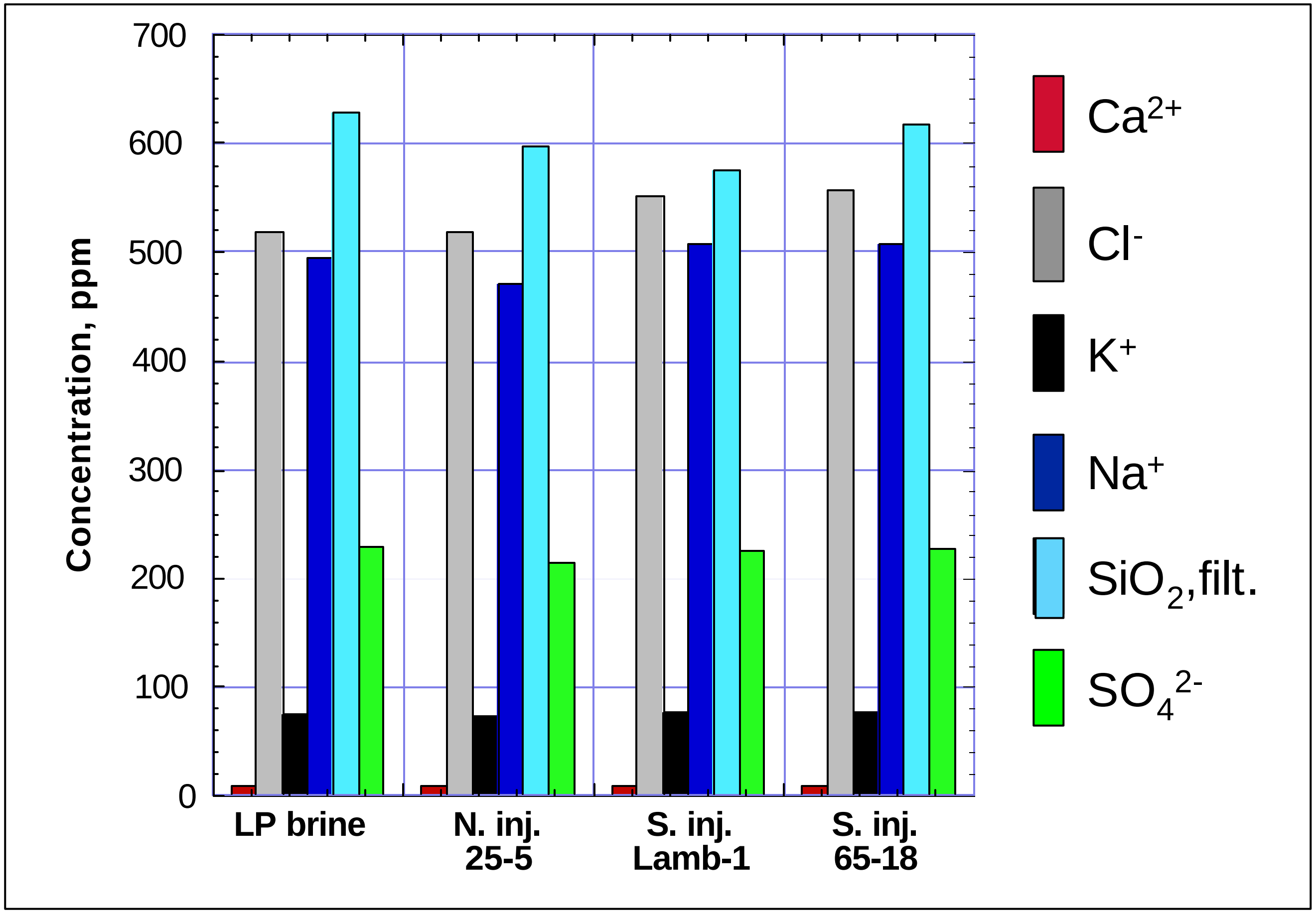
Objectives

- What is the source and composition of scale in injection lines? How can it be controlled?
- Will scale form if reinjection is supplemented with local shallow groundwater to maintain reservoir pressure? Can it be controlled through fluid mixing?
- Will reinjection damage the reservoir over time?

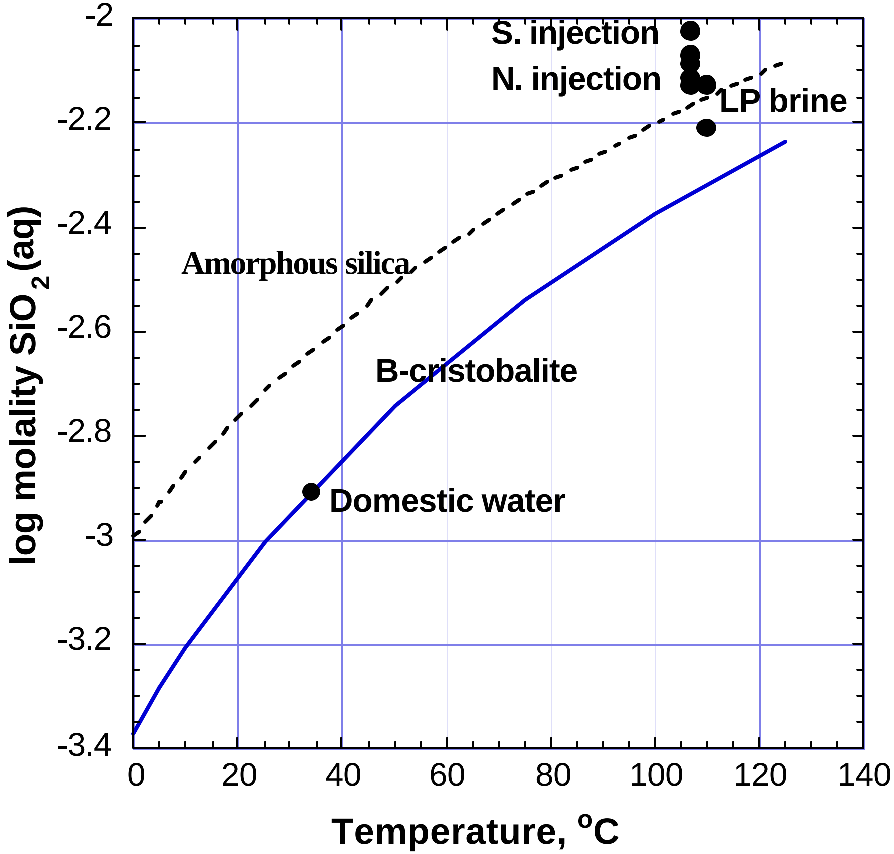
Chemical analyses of major components of test bed scales

Component	Inlet	"Aged"	Exit
Major components (in wt%)			
SiO_2	62.10	61.56	60.52
Al_2O_3	7.47	6.60	3.84
Fe_2O_3	4.64	3.29	5.82
MnO	0.172	0.197	0.091
MgO	2.88	4.75	10.82
CaO	4.07	3.50	3.64
Na_2O	1.19	1.06	1.08
K_2O	1.53	1.38	1.02
P_2O_5	0.035	0.031	0.033
Cl	0.113	0.058	0.121
F	0.033	0.067	0.183
S	0.136	0.130	0.109
Total organic carbon	0.272	0.172	0.180
Total inorganic carbon	0.083	0.065	0.282

Major element chemistry of LP and injection brines

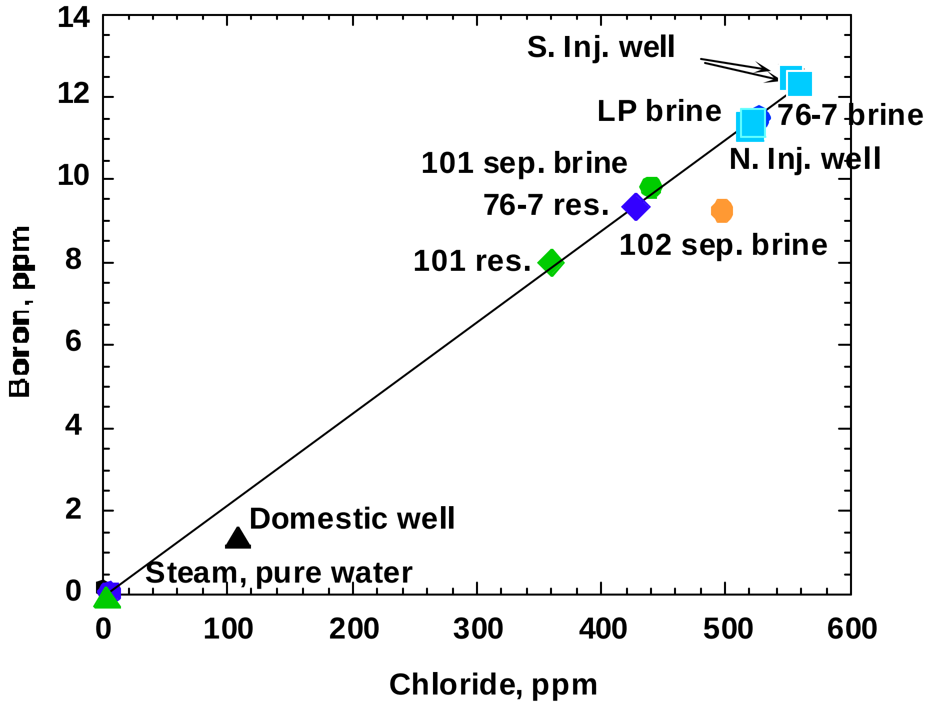


SiO_2 concentrations in production and injection brines



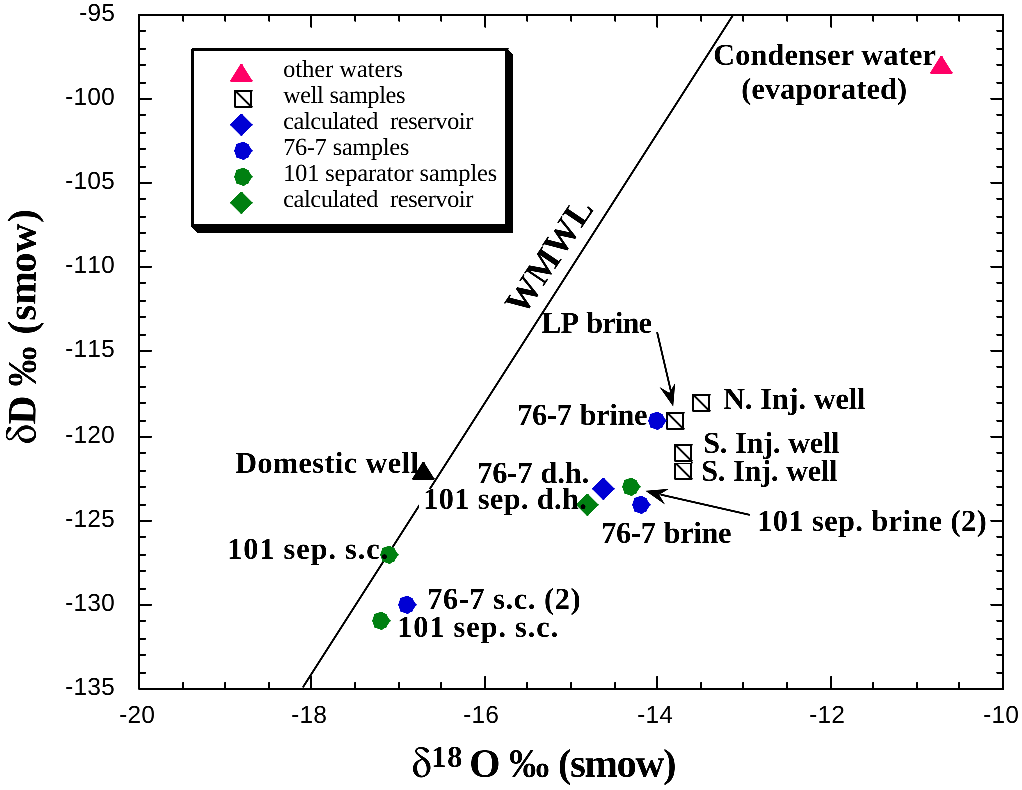
- Production and injection brines are close to saturation with amorphous silica
- SiO_2(aq) comprises only 58-92% of total silica owing to alkaline pH of brines
- Injection brines are more concentrated than LP brine
- Local shallow groundwater (domestic) is in equilibrium with a, b-cristobalite

Trends in conservative elements show relationships among Dixie Valley fluids



- Mixing/dilution line defined
- Domestic water is mixture of local recharge and approx. 15-25% reservoir fluid

Results of stable isotope measurements



- Reservoir fluids exhibit oxygen isotope enrichment (2-3 $^{0}/_{00}$) owing to rock-fluid interactions
- Recharge seems to occur locally
- Steam loss/mixing relate waters
- Injection waters seem to be slightly more concentrated than LP brine

Results of Cl isotope measurements

- $^{36}Cl/Cl$ of produced brines and low pressure brine is about 50 x 10^{-15}
- $^{36}Cl/Cl$ of local groundwater (167 x 10^{-15}) is higher than brines but lower than regional precipitation (> 320 x 10^{-15})
- Suggests that local shallow groundwaters are mixture of regional recharge and deeper geothermal brines
- About 12 % of sampled groundwater is geothermal brine, assuming regional recharge has 50 ppm Cl and $^{36}Cl/Cl$ of 320 x 10^{-15}

Results of d^{13}C and ^{3}H isotope measurements

- d^{13}C seems to result from mixture of carbonate and organic sources with isotopically enriched and depleted carbon, respectively.
  - d^{13}C of reservoir fluid and separated CO_2 equals -4.5/ -5.3 $^{0}/_{00}$, within range of mantle values.
  - Kennedy et al. (1996) found <10 % of reservoir He is mantle-derived (R/R_A 0.7-0.76).

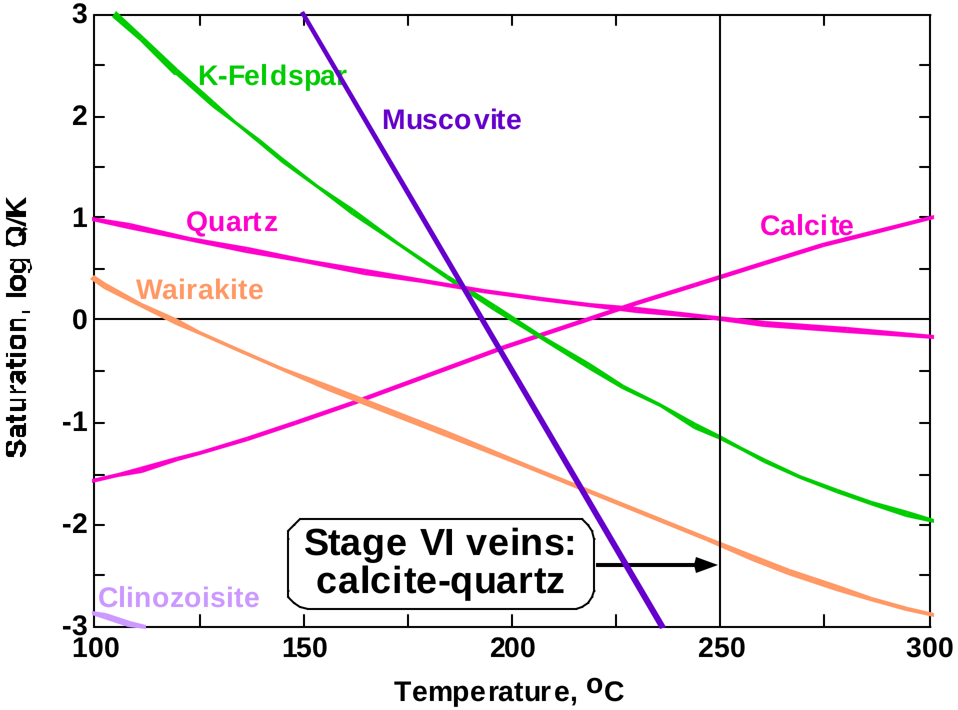
- ^{3}H (tritium) is very low (0.10 T.U.) in reservoir fluids, which suggests minimum mean residence time 75 years and maximum of 10,000 years using piston flow and well-mixed reservoir models, respectively.

Lines of evidence for component of reservoir brine in domestic water

- $^{36}Cl/Cl$ results suggest that about 12% of sampled shallow groundwater (domestic water) is geothermal brine
- Mixing/dilution relationships between trace elements and Cl suggest that shallow groundwater contains 15 - 25% geothermal brine
- Shallow groundwater has high HCO_3, SO_4, Ca

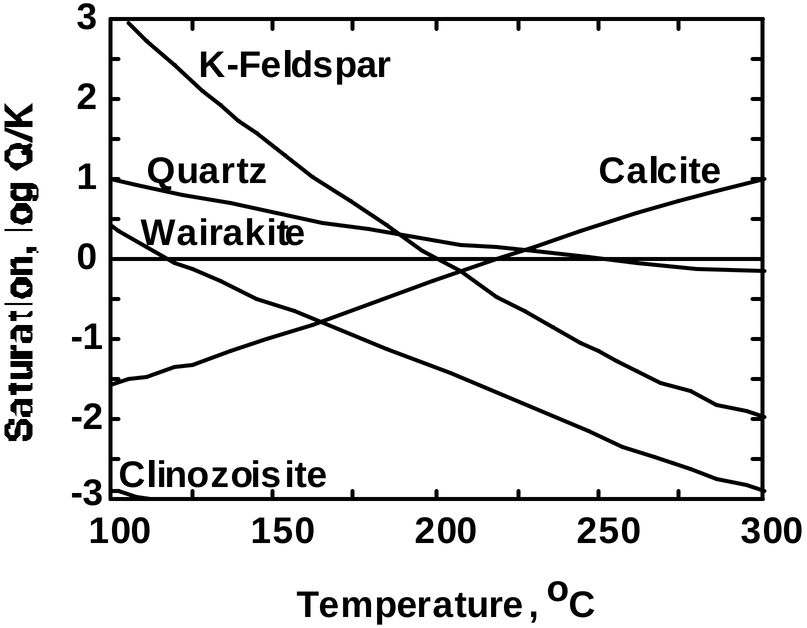
Conclusion: Local shallow groundwater contains about 15% geothermal brine mixed with regional recharge

Predicted mineral alteration in present-day geothermal system: Well 76-7

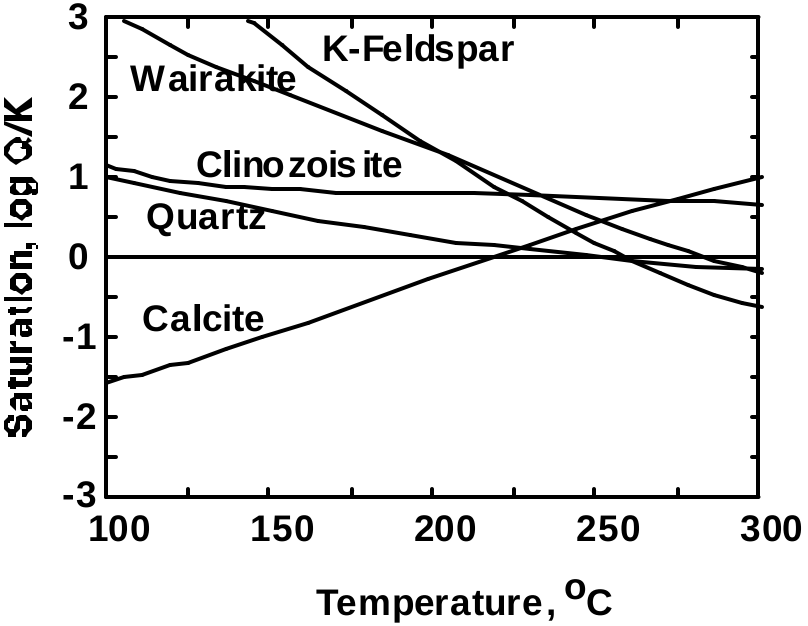


- Quartz is at equilibrium and calcite is slightly supersaturated in reconstructed reservoir fluids from well 76-7.
- Mineralization agrees with Stage VI calcite-quartz veins (Lutz, 1997)
- The alkaline pH of the reservoir brine precludes precipitation of aluminosilicates

Choice of Al concentration controls predicted mineral alteration in present-day geothermal system

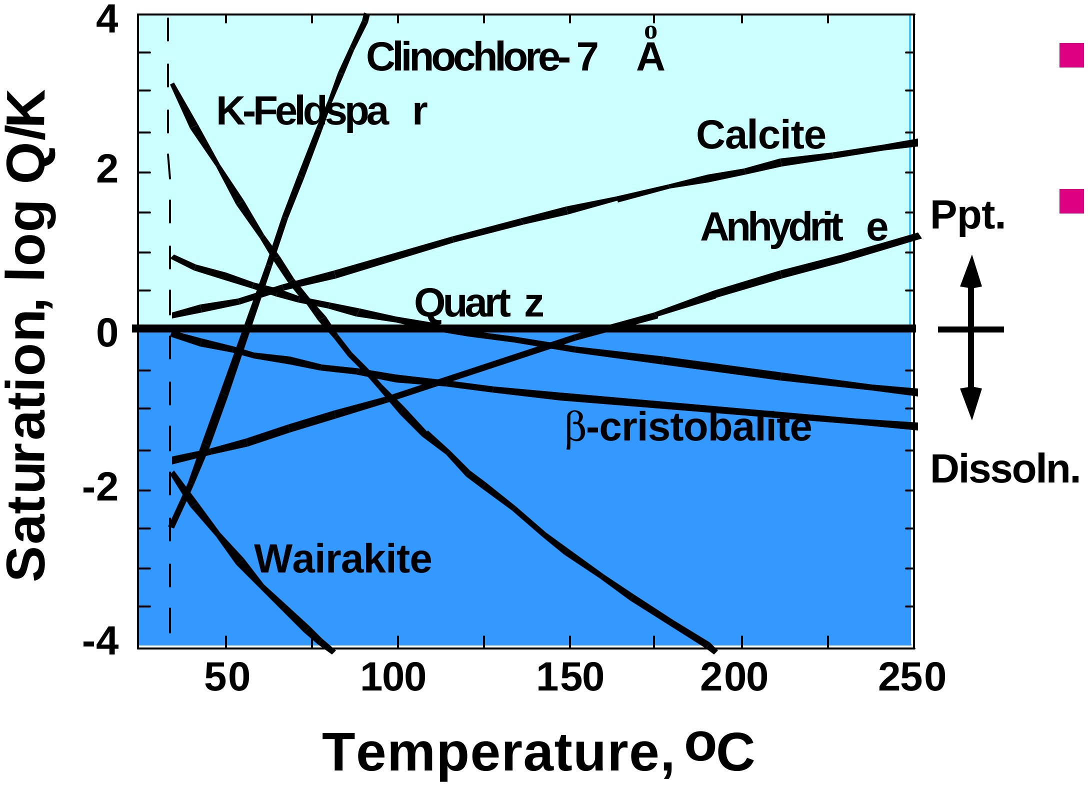


Monomeric Al = 0.041 mg/kg



Total Al = 0.916

Consequences of heating of domestic water



- Carbonates, sulfates and Mg-silicates tend to precipitate
- Silicates such as quartz become increasingly undersaturated

Conclusions

- **Local shallow groundwater contains about 15% geothermal brine mixed with regional recharge**
- **Recharge to the Dixie Valley system seems to occur from local sources**
- **Scale is dominated by amorphous silica**
- **The LP brine and injection waters are saturated with amorphous silica, which correlates with the ongoing scaling problem**
- **Downhole fluids seem to be in equilibrium with calcite and quartz, which is consistent with current mineralization**
- **Mineral precipitation will likely occur if domestic water is reinjected into the reservoir and/or heated**